DOCUMENT RESUME

ED 275 489 SE 046 897

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TITLE The Gulf of Maine in the Classroom.
PUB DATE [86]
NOTE 11p.
PUB TYPE Reports - Descriptive (141)

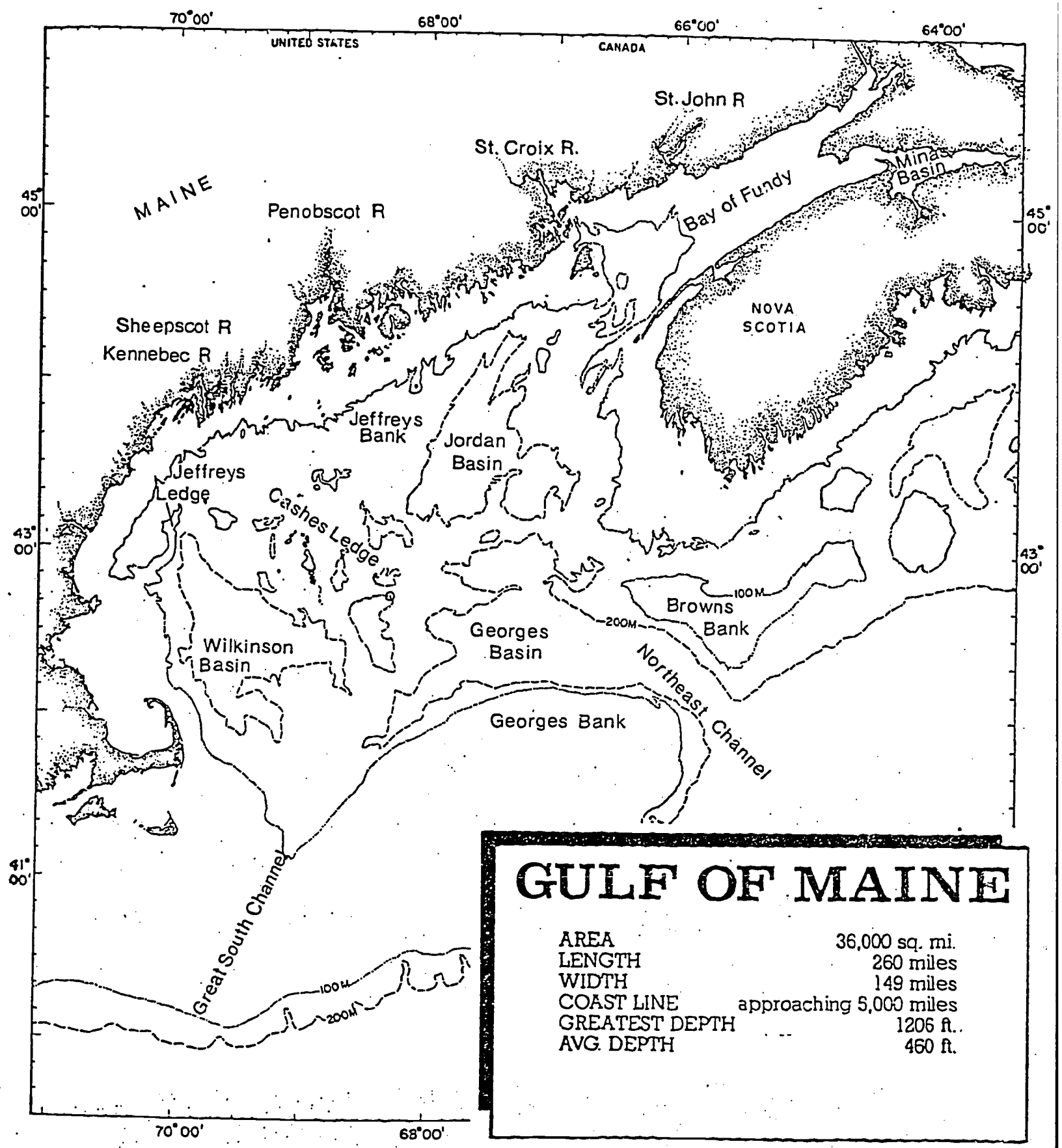
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Concept Formation; Decision Making; Ecology; Elementary Secondary Education; *Environmental Education; Geology; Marine Biology; *Marine Education; *Misconceptions; *Natural Resources; *Oceanography; Physical Environment; Science Education; Scientific Concepts; Water
IDENTIFIERS *Gulf of Maine; *Science Education Research

ABSTRACT

This paper describes some of the correct, missing, and alternative conceptions which students possess related to the Gulf of Maine. Students (N=226) from grades 4, 8, and 11 were interviewed on 15 major concepts involving geology, physical and chemical oceanography, natural resources, ecology, and decision-making. The mean interview scores of the student responses were low and reflected little or partial understanding of the concepts. There was only minor improvement of student understanding through the grades and little transfer of this knowledge to current marine topics. This paper also highlights selected aspects of the Gulf's geology, ecology, and economic development. A list of curriculum materials that were designed to provide teachers with background information and classroom activities related to the Gulf of Maine are also included. (ML)

GULF OF MAINE IN THE CLASSROOM

Michael J. Brody



GULF OF MAINE

AREA	36,000 sq. mi.
LENGTH	260 miles
WIDTH	149 miles
COAST LINE	approaching 5,000 miles
GREATEST DEPTH	1206 ft.
AVG. DEPTH	460 ft.

Introduction

The ocean is a familiar and essential part of life in our coastal states. It has molded our past and continues to shape our future. Because of the ocean's multiple influences on people, it provides living models in a wide range of subjects including geology, biology, oceanography, ecology, natural resources, fisheries and international law. Teachers may use the highly integrated relationships in the marine world, which can be made a familiar part of schoolchildren's heritage, to illustrate complex intellectual concepts. By so doing, teachers are able to bring science into a familiar context and enhance student understanding.

The coastal areas of the U.S. provide specific examples of many concepts that are presented in textbooks in very generic ways. For example, the ecological concept of productivity takes on added meaning when coral reefs in Hawaii, salt marshes in Georgia or tide pools in Maine are used to teach children who are familiar with their local environments. In the Great Lakes, the concepts of thermocline, sportfishery and management are important ideas for our next generation of salmonid sport fishermen to understand. Teachers' use of marine examples can greatly enhance children's learning of basic natural and social science concepts. In searching for one such example in the northeast portion of the United States we find the Gulf of Maine. This important area provides an outstanding opportunity for teachers to use a unique marine system to teach geological, physical, chemical, biological, ecological and social concepts.

From a pedagogical point of view, it is important to note that students acquire a vast array of conceptions before and during their school years. These ideas which students possess concerning the ocean realm may be scienti-

fically correct or incorrect. In any event, they are robust and very resistant to change. They form part of a large framework of ideas that the student possesses which influences what the student will learn in relation to instruction. This paper describes some of the correct, missing and alternative conceptions which students possess related to the Gulf of Maine. These ideas form a solid framework on which to build classroom activities to teach about this unique system.

The Gulf of Maine

About 15,000 years ago, the Ice Age glaciers retreated and left behind a remarkable marine environment: the Gulf of Maine. It is a body of water 70 percent enclosed by New England and Canadian geological formations. The Gulf of Maine is set apart by the continental land masses and also separated from the North Atlantic Ocean. Georges Bank and Browns Bank form an effective barrier running from Cape Cod to Nova Scotia. These banks which are located far offshore rise close to the sea's surface and prevent a widespread mixing of water between the Gulf and the Atlantic. The Gulf of Maine is really a "sea beside a sea".

As the glacial ice sheet receded, meltwater etched river valleys like the Kennebec, the Penobscot, and the St. Croix, while at the same time the ocean's level gradually rose. The advancing sea filled in Penobscot and Casco Bays and flooded low-lying areas. Over the next five thousand years, land surfaces relieved of the weight of the glaciers slowly rose and the ocean waters receded to a position approximating the coastal region much as we know it today. Encompassing 36,000 square miles from Cape Cod north and east to Nova Scotia, what was known by early European explorers as simply a rich fishing ground is now known as the Gulf of Maine.

Today the Gulf is home for a complex ecological community made up of

diverse open water populations with both benthic (bottom) and pelagic (water column) species. As a result of a variety of factors resulting in well mixed nutrient rich water, the Gulf supports one of the most productive fisheries in the world. It is exploited today by both commercial fishing operations and sportfishing enthusiasts. The Gulf of Maine provides an efficient water transportation system for shipping oil, gas, coal, and peat in large volume. The deep-water harbors which characterize the Maine coast are not found elsewhere on the eastern seaboard of the United States. In addition, the high tides and rivers of the Gulf (especially the Bay of Fundy) provide an opportunity for tidal power and hydropower development in a region with little or no natural hydrocarbon resources. Finally, the Gulf of Maine offers the people who live along its shores a source of livelihood and recreation as well as an appreciation for its multiple riches.

For centuries the U.S. and Canada shared the resources of this wonderfully productive area. However, during the late 1970's and early 1980's a series of events, including the leasing of the offshore ocean bottom for oil exploration by the U.S. and Canada, led to a dispute over ownership of particularly valuable areas. Each country claimed important natural resource areas for their own exploitation. In 1984, the International Court of Justice established the U.S./Canadian maritime boundary. The fishing grounds were divided and today each country guards their territory. The U.S./Canadian maritime boundary decision in the Gulf of Maine, with its far reaching consequences into most areas of marine life, provided the focus for this study.

A Classroom Based Study

A team of students in the College of Education at the University of Maine has been working with public schools to determine what students do and

don't understand about the Gulf of Maine. The Northeast Marine Education Program (NEMEP) research team interviewed 226 students equally divided among grades 4, 8, and 11 in 12 public schools. The interview format was determined by analyses of primary documents (legal briefs) concerning the Gulf of Maine which were presented by the U.S. and Canada to the International Court of Justice at The Hague, Netherlands.

Each half hour student interview covered 15 major concepts of geology, physical and chemical oceanography, natural resources, ecology, and decision-making. These concepts are considered to be essential to a full understanding of the Gulf of Maine, its productivity and the boundary decision. Each student interview was audio-taped and analyzed. It should be noted that this research does not represent survey techniques of an entire population; however, the qualitative results of student knowledge describe what we believe to be essential information for the effective design of future marine education programs. The mean interview scores of student responses for the 15 marine concepts at each grade level were low and reflected little or partial understanding of the concepts. Overall totals of student responses indicated that students in fourth, eighth and eleventh grade understood only a few basic science and natural resource concepts. There was only minor improvement of student understanding through grades and little transfer of this knowledge to current marine topics. The research team constructed generalized student statements of correct understanding for each of the fifteen marine related concepts; these partially correct statements indicate many important ideas missing from the students intellectual grasps. For example, students did understand that Canada and the U.S. border the Atlantic Ocean. However, all students were missing the concepts of banks and shoals. Since the Gulf of Maine's productivity is, in part, a result of it being separated from the Atlantic Ocean by Georges and Browns Banks, it would be

very difficult for students to fully understand this marine system without first learning about ocean bottom topography.

Students' misconceptions were also identified. These are erroneous ideas which can signficantly impede future learning. A common misconception involved coral reefs and their existence throughout the Gulf and North Atlantic. Since cold, nutrient rich, turbid, green water and coral reef formation are mutually exclusive, this misconception must be addressed before students can fully understand the concept of productivity in the Gulf of Maine. From our results, it is clear that students learn a few basic science concepts in elementary grades which they have great difficulty applying to issues concerning marine resources. In addition, students do not seem to acquire new concepts or learn to differentiate among discrete concepts as they progress through school.

Student misconceptions and partial understandings form the major target for the design of future marine education programs focusing on the Gulf of Maine. Teachers who are developing marine education activities can build on what we know students understand about the ocean and specifically address certain misconceptions. For example, our results indicate students have a rather rich understanding of water movement in the ocean. Wind and tides are frequently cited as the primary causes of currents. Based on this information it is easier to address the unique circulation characteristics in the Gulf of Maine which contribute significantly to the tremendous amount of primary productivity. After all, nutrients would not be available and water temperatures would not be so uniformly cold as well if the waters were not well mixed by tidal currents and wind driven surface currents.

Conclusion

The results of the study can be used by educators to more effectively

introduce marine concepts to students based on their existing knowledge of the subject. The results can facilitate more effective learning in marine education activities. A detailed report, including tables of the 15 essential science concepts related to the Gulf of Maine, existing student knowledge, missing concepts and misconceptions, is available from the Northeast Marine Education Program (NEMEP), 206 Shibles Hall, University of Maine, Orono, Maine 04469.

Curriculum Materials

Through NEMEP and the University of Maine Sea Grant Program teachers may request copies of multidisciplinary marine education curriculum units which focus on the Gulf of Maine. These materials have been designed to provide teachers with sufficient background information and classroom activities to teach units or infuse related to the Gulf of Maine into their curriculum. These units include:

What Is Our Maritime Heritage?

How Do People Use Lighthouses and Navigational Charts?

Is Our Food Future In the Sea?

Do You Know Our Marine Fishes?

Do You Know Our Marine Algae?

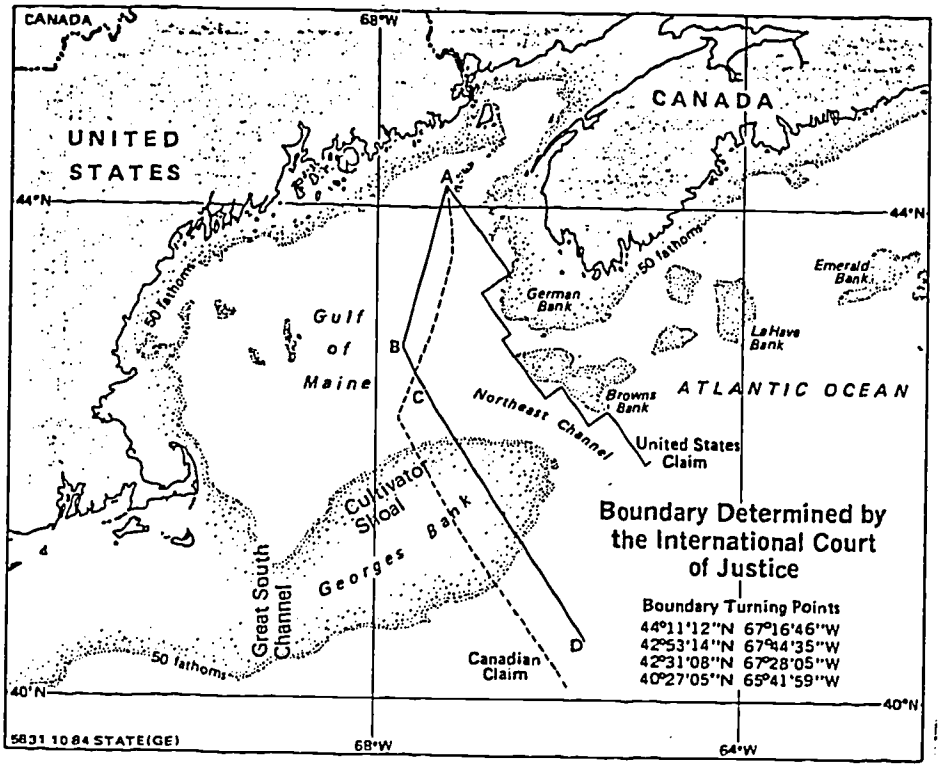
What Are the ABC's of Marine Education?

Have You Been to the Shore Before?

In addition, two recently developed half hour video tapes suitable for presentation in middle or senior high school classrooms are available. These are:

The Gulf of Maine: A Sea Beside A Sea

The Gulf of Maine: Not Just Another Fish Story


CANADA
68°W
UNITED STATES
CANADA
44°N
44°N
A
B
C
D
50 fathoms
50 fathoms
Gulf of Maine
German Bank
Emerald Bank
LaHave Bank
Browns Bank
ATLANTIC OCEAN
Northeast Channel
United States Claim
Cultivator Shoal
Georges Bank
Great South Channel
50 fathoms
Canadian Claim
Boundary Determined by the International Court of Justice
Boundary Turning Points
44°11'12"N 67°16'46"W
42°53'14"N 67°44'35"W
42°31'08"N 67°28'05"W
40°27'05"N 65°41'59"W
40°N
40°N
5831 10 84 STATE(GE)
68°W
64°W

Content Principles to be used in the analysis of interviews

1. The Gulf of Maine is separated from the Atlantic Ocean by Georges Bank and is bordered by the coastlines of the U.S. and Canada.

2. The ocean bottom is continuous with the continent, has a slope, gets progressively deeper, and is interrupted by bottom features such as channels, banks and shoals.

3. Ocean water in the Gulf of Maine is characterized by low temperatures, low salinity, which is primarily the result of freshwater inputs from the continent.

4. Ocean water in the Gulf of Maine is nutrient rich.

5. Water in the Gulf of Maine moves because of wind-driven currents, river inputs and tides, which collectively result in upwelling and uniformally mixed waters.

6. Energy flows through this system from the sun to plants to animals.

7. Within the system, plants capture light energy and convert it to food.

8. Within the system, plants and animals interact in a complex food chain and web

   (primary producers —— herbivores —— carnivores —— man)
   (plants —— grazers —— meat eaters —— man)

9. The Gulf of Maine contains valuable living and nonliving resources that man has exploited over several generations.

10. Renewable resources in the Gulf of Maine (fish, seals, lobsters, seaweed) have been harvested using a variety of traditional techniques (drags, traps, nets).

11. Non-renewable resources, such as hydrocarbons and gravel, are being considered for exploitation.

12. The Gulf of Maine is also considered valuable for recreation, research, tourism, and other non-consumptive resource users.

13. The Gulf of Maine has traditionally been utilized as a common resource by many nations, and currently there is a conflict over the future utilization of these resources.

14. Desputes over resources can be negotiated by concerned parties through mutually agreed upon decision-making (negotiation).

15. In order to insure a balanced system, management strategies based on conservation and utilization must be practiced in an equitable manner.